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## ON CERTAIN PECULIARITIES IN THE FLORA OF THE SANTA BARBARA ISLANDS.

BY J. WALTER FEWKES.

THE study of the distribution of terrestrial life on islands has always been a prolific one in theoretical discussions of the origin of species. Darwin and Wallace both drew from this source most interesting conclusions in regard to their theories, and from it are still derived some of the most suggestive facts bearing on questions of geographical distribution, migration and preservation of genera and species.

This is particularly true of oceanic islands separated from continents by wide expanses of the ocean or of chains of islands connecting continental land-masses. The peculiar assemblage of life in Saint Helena, the Galapagos or the Bermudas contribute most important data to the general discussions of the derivation and modification of faunas and floras in isolated tracts of land in the ocean. It thus happens that the study of islands has always had a profound fascination to the investigator of the variations of life on the earth's surface.

As a general thing the terrestrial life of continental islands resembles that of the neighboring land-masses. The very contiguity would seem to imply a colonization of one from the other, and therefore a resemblance, since the ease with which genera and species can be transported across intervening water is an all

sufficient cause for a similarity. While there is evidence that the basins of the great oceans have always been approximately the same as they are at present, the fringes of the continents, or the platforms upon which continental islands rest, have, from time to time, suffered changes of elevation which, in many instances, have raised the intervening sea bottom above the surface of the water, and thus have brought about a means of communication for the life of continents and neighboring islands. In this case it is not necessary to call in the aid of various means of transportation across intervening bodies of water, straits and sounds, for the commingling of the two floras and faunas. Prehistoric man in his early migrations, no doubt, was profoundly affected by a law of distribution similar to that which influenced animals and plants. Using islands as stepping stones he may thus, before he had the hardihood to attempt the ocean in navigation, have even passed from one continent to another at a time when portions of the shallower ridges of the ocean floor now submerged were elevated above the sea. In this way, for instance, he may have migrated on dry land from northern Europe to Greenland and then to the North American continent, or, in a similar way, across what is now Behring Strait and the Aleutian Islands from Asia into Alaska. The possibilities of inter-communication between lands not separated by the abysses of the ocean for races of man, animals and plants are very great, and can only be read in the light of the great geological changes which have occurred on the margin of continents in which elevation and depression have undoubtedly taken place.

Islands which have become separated from the continents by submergence of the land, or by erosion and a cutting out of an intervening channel, preserve, in a measure, the fauna and flora of the adjacent continents, but they are independently affected in somewhat different ways by the struggle for existence of their inhabitants. New conditions may arise or old ones may persist which may or may not lead to the preservation of organic forms which have been exterminated on the adjoining continent. Inter-communication, however, between the two has always had an influence in neutralizing the changes which might otherwise occur.

It may, on the other hand, happen, when islands preserve uniformly the past conditions of the mainland for a longer time than the continents, that their fauna and flora resemble an older assemblage of life of the land of which they are a part, and with which they were formerly connected.

It is believed that the Santa Barbara islands illustrate this latter statement. Climatic changes have, it is thought, taken place on the mainland which have changed the environment<sup>1</sup> to that extent that animals and plants once found there have succumbed and disappeared, while these conditions have remained more constant on the islands, where, as a consequence, the destruction of certain organisms has not been so rapid.

It may be borne in mind, however, that the causes which have led to the restriction of certain plants or animals to circumscribed localities in other parts of the world are not all understood. This restriction or local distribution may be due to general or to local causes, yet the former may at times be called to aid when the latter are insufficient. In New England, for instance, a local distribution of certain plants in limited areas often occurs and no explanation can be discovered for their limitation. It must, therefore, be with diffidence that one finding peculiarities in the flora of certain islands ascribes those characteristics to far-reaching rather than local influences. Especially must one use caution in the study of phenomena in which more facts are necessary. The following paper, however, uses the data given by others, but with this precaution, knowing that such speculations may be overturned by new observations and more extended studies bearing on the peculiarities of the flora of the islands.

Of the later geologic phenomena which have been called in to account for the present distribution of animals and plants, the glacial period is one of the most important. Possibly too great influence has been ascribed to it on account of the nearness of this period to the present, which it might be expected to most

<sup>1</sup> In environment are included organic as well as climatic changes. The organic environment makes itself felt in a struggle for existence, which counts for as much as, if not more than, climatic changes.

profoundly affect. Looking back into the past, it is the first climatic change which offers great differences of condition from the present.

One of the consequences of the advance and retreat of the great ice sheet which once covered the northern latitudes of North America, is its influence on the distribution of terrestrial life. It is argued that the advance of this ice sheet must have forced southward hardy animals and plants which, when brought into competition with southern species in a struggle for existence, led, through inheritance, to important modifications in the general aspect or facies of the fauna or flora of any given region. In a somewhat like way a retreat of the ice sheet towards the north may be supposed to have enlarged the area for life, and to have drawn with it those organisms which find colder latitudes more congenial to their lives, and thus opened a way to changes in the character of the life inhabiting the areas vacated by them. The survival of Alpine floras and faunas on mountain tops finds a ready explanation in a distribution brought about primarily by the latter of these causes, viz.: the retreat of the glacial ice sheet to the polar regions, and the resemblance of the conditions of those high altitudes to formerly existing in the valleys.

In a discussion of the causes of the peculiar flora of the Santa Barbara Islands pointed out by Prof. Greene, Prof. LeConte<sup>2</sup> has adduced the aid of the glacial period and ascribed this peculiarity to the survival of an old flora on the islands, while that of the neighboring continent has been more or less modified by a struggle with hardy denizens forced into it by glacial conditions. His reasoning on this point seems to me cogent and conclusive in general, but not wholly adequate in the special case of the peculiarities of the flora of the Santa Barbara Islands. It is believed that he is right in the supposition that the present flora of Santa Cruz more closely resembles that which once existed on the contiguous coast than it does the present flora of the same locality. The remoteness of the continental glacier as indicated by its terminal moraine must have been great from the region under discussion, and the possibility of its influence on the equilibrium

<sup>2</sup> *Amer. Journ. Arts and Sciences.* Vol. XXXIV.; pp. 457-461.

of life so far away is small. It may be well to look about in order to discover, if possible, other causes nearer the locality for an explanation of this destruction of continental species and the survival of older characteristic genera on the neighboring islands. I think there are other and possibly more effective causes which have had a profound influence in Southern California in this direction.

When hardy<sup>3</sup> species were driven south by glacial cold, they were certainly more fitted to survive in the cold climate than the denizens of a warmer climate which they encountered, simply because the climate was colder. But when the glacial cold was mitigated the animals and plants of warmer climates were more fitted to survive, and in a struggle for existence would be stronger than the "hardy" or those fitted for glacial cold or comparatively low temperatures. Then their influence would be greatest. As the character of the insular flora was less affected than the main land by the hardy animals, we may also suppose it to be less affected than the main land by the return of the warm climate animals at the restoration of a more genial climate. Consequently, not only glacial cold but subsequent milder temperature have acted in unequal degrees upon the inhabitants of islands and main land. If there was a return of conditions of climate similar to that of the Pliocene, like plants to those of the insular flora might be expected to reappear. But a new influence has made itself powerful in modifying environment. The main land has become more desiccated than it formerly was. From the nature of their position the islands are not as profoundly affected by this influence as the continent. Like a huge Briaræus desiccation has spread itself over the south-west, so that, while its influence is exerted on the insular flora, it is not in as marked a manner as on the main land. So potent is this influence that it cannot be lost sight of, and is even as important as glacial cold. We must not forget, also, the profound influence on climate, and, consequently, on the facies of organic life, which the out-pouring of

<sup>3</sup> More suited to live under conditions of glacial cold. "Hardy" genera may, under condition of heat or dryness, become feeble. The word as here used, means organisms which are more fitted to live in cold climates.

the great lava beds may have had. As glacial cold had its influence, the heat resulting from these out-pourings was not without its effect.

The great arid deserts of our south-west, which extend into California, and make their influence felt even to the coast, have had a most important influence in the determination of the character of the fauna and flora of Southern California. This influence has exerted itself in much the same way as the cold<sup>4</sup> of the glacial epoch. The drying up of great tracts of land necessarily led to a crowding of the denizens of the tract thus desiccated into regions not so greatly affected. The result of an influx of individuals intensifies there a struggle for existence, and leads to extermination of less fortunate or weak genera and species. The regions most distantly removed from the most arid regions would necessarily be least affected by the increased desiccation, and on these out-posts of the continents, the islands, where the environment is least modified by this climatic change, we can look for the survivors of the old faunas and floras. The results arrived at by this *a priori* reasoning are exactly what Mr. Greene finds in the distribution of the plants on the Santa Barbara Islands. From his study of the plants of these islands, more especially Santa Cruz, the following, among other conclusions, are derived:

1. Forty-eight out of two hundred and ninety-six species of plants collected are peculiar to these islands, and twenty-eight are peculiar to Santa Cruz.
2. All the species are distinctly Californian, and those species which are now found in small numbers in a straggling condition on the neighboring mainland are very abundant on the island.
3. The genus *Lavatera*, of which eighteen species are known in the Mediterranean region, and one from Australia, is represented by four species on the island of Santa Cruz. *There is not another known species from the American continent.*

There is also a significant fact which is believed to bear on our discussion, viz.: the distribution of land shells on the islands and the neighboring mainland. Indefatigable collectors of West

<sup>4</sup> Waiving the question of whether the glacial period was or was not one of great cold.

Coast shells have not been able to collect land shells near Santa Barbara, and yet on the neighboring islands many of these mollusks are found, notably, a peculiar species of *Helix*, which, unfortunately, is rapidly being exterminated by the sheep. The presence of these shells on the island, and their absence on the mainland, I suspect, point the same way as the peculiar distribution of the plants, and seem even as significant of the character of the change in the climatic condition of the environment.

The arguments which have been advanced by others to support the proposition that our arid deserts were once better watered than at present, are not necessary to quote here. That these deserts were not always as dry as at present seems to me proven, and the zoological facts in the distribution of the island life look indeed as if such a desiccation has left its mark on the distribution of genera and species.

In view of the distance of the land of Southern California from the sources of glacial cold,<sup>5</sup> it seems difficult to suppose that the equilibrium of life in this low latitude was much affected by this temperature. There are marks of local glaciers on the flanks of the Santa Inez Mountains, and the observer has not to go far from Santa Barbara to find what may be regarded as their moraines, but traces of a continental glacier are believed not to exist in this low latitude. These local glaciers may have driven hardy forms into the valleys by their advance, but it is hard to suppose that to this cause alone a comprehensive change in the flora or fauna has resulted. Desiccation of the climate, however, is a phenomenon of wide distribution in the south-west, and its influence must have been far reaching and great enough to lead to wide-spread modifications in the facies of faunas and floras.

If we ascribe the preservation of the older or partial Pliocene flora in the Santa Barbara Islands to their still retaining a moist climate from the vicinity of the ocean, it may be asked why the adjoining coast, by its situation, is not also acted upon by the same influence? Why are not these same plants protected there as well as on the island, since the vicinity to the ocean may have

<sup>5</sup> Evidence has been rapidly accumulated that the intensity of the so-called glacial cold was not great.



exerted the same influence? To this it can be answered that in places they are so protected, and Mr. Greene has mentioned instances where these insular forms still exist. These scattered localities are not regarded as points where the island genera have migrated to the mainland and there obtained a footing, but as preserving the same congenial influences which have made it possible for them to survive on the islands. It seems to the author that the theory that the preservation of these scattered remnants of the old life is exactly what would result in places on the shore. They are remnants of a flora once widely distributed throughout California.

These straggling colonies of characteristic insular flora are found, according to Mr. Greene, in isolated patches in San Diego and San Bernardino counties. These are supposed by him to be incipient colonizations on the mainland from the islands. Prof. LeConte, on the other hand, regards these patches as survivors of the Pliocene indigenes which have not followed the fate of their relatives, and the situation of these patches of 'older life in the southern counties, according to the latter, is "just what we might expect, for the main invasion [of hardy forms resulting from the influx due to the glacial cold] was from the north." There seems no valid objection to considering these survivors as remnants of the flora of a former geologic period sheltered by environment from destruction, but the causes which have led to the modification of their associates may not wholly be due to the influences of the glacial period. The other influence is continental desiccation.

The islands have, no doubt, been affected by the dessication of the continent, but not in the same degree as the mainland. Their fauna has changed, no doubt, since they were connected with the mainland and the mammoth was found on both, but not to the same amount. The sea, with its fogs and local evaporation, has counteracted, in a measure, the drying up, which has been most marked at a distance from the sea.

In conclusion, while accepting in the main the theory that glacial cold has had an influence, I would suggest that the main cause of the peculiar flora of Santa Cruz Island, observed by Mr.

Greene, is the change which has come to Southren California by the desiccation of the land. The islands, less acted upon than the main, from position and the neighborhood of the ocean, have, on that account, preserved a flora possibly like the Pliocene once found on the adjoining continent. As the environment changed on the main-land many of the genera died out, but they still persist where conditions are less modified because offset by local causes.

It does not seem necessary to suppose that the islands are remnants of a new centre of distribution of life, or that it is wholly explanatory of the peculiarity of the flora to ascribe the extinction of the same plants which now exist on Santa Cruz to a struggle with hardy varieties forced southward by glacial cold. The drying up of the climate is a potent factor which had a great influence and is sufficient, with other causes, to bring about great changes. As high mountains may be regarded as preserving an Alpine flora left in a congenial position by the retreating glacier, so the Santa Barbara Islands may, in a somewhat different way, present us a life preserved in sheltered points by the drying up of the neighboring sections of the continent which has less strongly affected the islands than the main-land.

But neither of these causes alone is adequate to explain the peculiarities of flora or fauna in any circumscribed locality. There are many influences at work, and causes even which may have their origin far away from the regions which they effect. To analyze this nexus of influences is next to impossible. In a broad way we may say that the present facies of the fauna and flora of any circumscribed locality is primarily the result of environment, and where environment changes organic forms must change, while, when it remains constant, less modification is the result. A marked climatic change such as followed the drying up of a great area of such extent as has taken place in our southwest, leaves its mark on the organisms near and remote from it.

Two questions must be answered positively to make our reasoning logical. Has a desiccation taken place? and is it as great on the islands as on the main? Both of these questions are believed to be capable of definite answers. Desiccation has

taken place, and it has not been as great on the islands as on the adjoining continent. There remains at least one fact to be determined, and for its acceptance additional research is certainly necessary. The flora of the Santa Barbara Islands is said to differ essentially from that which at present exists on the neighboring main-land of California. What is the relation of the present flora of California to that of the Santa Barbara Islands, and what was the flora of the main-land, especially in the Pliocene Age? Has there been an intercolonization of islands and continents since that glacial period? These are questions to be answered, but the most important one of all is, "Are any of the plants of the islands peculiar to them?" The above paper accepts the observations of others that they are. It seeks to point out a cause more potent than any yet suggested, to account for peculiarities of this insular flora if such peculiarities exist.

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## THE TEETH AS EVIDENCE OF EVOLUTION.

W. C. CAHALL.

**I**N the August number of *Lippincott's Magazine* appeared a paper by W. G. A. Bonwill, entitled "Why I Deny Evolution." The argument is based upon the structure of the teeth and their relation to the human jaw.

It would be as incomplete to confine your argument in support of the law of gravitation to a single phenomenon, *e. g.*, shooting stars, as to rest your plea for evolution upon the human jaw. It is manifestly unjust to the proper appreciation of a great doctrine like Evolution to deliberately deny oneself the great wealth of evidence furnished by Geology, Embryology, Rudimentary Organs, and the Comparative Anatomy of the several organs of the animal economy; yet it would be equally unfair to Dr. Bonwill to meet his argument upon any other ground than that upon which his argument is based, the human jaw.